# REVIEW OF THE COLUMBIA/SNAKE RIVER TEMPERATURE TMDL FOR THE COLVILLE AND SPOKANE TRIBES

*Prepared for*

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## INTRODUCTION

A meeting was held on August 6, 2002 in Spokane, Washington between EPA Region X and representatives from the Colville, Spokane, and Kalispel Tribes concerning the Columbia/Snake River Preliminary Draft Temperature TMDL (EPA, 2002). Also in attendance were representatives from Washington State Department of Ecology (WA DOE), Columbia River Inter-Tribal Fish Commission (CRITFC), and Tetra Tech. The purpose of the meeting was to review tribal concerns regarding the effects of implementing the temperature TMDL on tribal resources, and to assess whether the TMDL model would be adequate to address these issues. Technical assistance was requested from Tetra Tech to provide an independent review of the TMDL modeling and to address the tribal concerns. A list of issues and questions were summarized from the meeting and formed the basis for the review.

A follow-up meeting was held in Spokane on September 6, 2002 to discuss the results of the review. In addition to the Colville and Spokane Tribes, representatives from the Nez Perce Tribe also attended the meeting. This report summarizes the meeting discussions and provides recommendations for future studies that could be done to address tribal concerns over the TMDL implementation. Table 1 lists the attendees at the two meetings, and Table 2 lists the major issues that were discussed.

## DESCRIPTION OF TMDL MODEL

The Columbia/Snake Rivers Temperature TMDL used EPA's RBM 10 model for the analyses. RBM 10 stands for **R**iver **B**asin **M**odel for EPA Region **10**. RBM 10 is a one-dimensional model that predicts the cross-sectional average temperature at different locations along the length of the Columbia and Snake Rivers. Because it is a one-dimensional model, it only deals with temperature changes along the lengths of the rivers.

**Table 1**
**Attendees at August 6 and September 6 Meetings**

| Name | Affiliation | Aug 6 Meeting | Sep 6 Meeting |
|---|---|---|---|
| Mary Lou Soscia | EPA | ■ | ■ |
| Rick Parkin | EPA | ■ | ■ |
| Helen Rueda | EPA | ■ | |
| Nancy Lui | EPA | | ■ |
| Gary Passmore | Colville Tribes | ■ | ■ |
| Sheri Sears | Colville Tribes | ■ | ■ |
| Patti Stone | Colville Tribes | ■ | ■ |
| Brian Crossley | Spokane Tribe | ■ | ■ |
| Tom Lorz | CRITFC | ■ | |
| John Gross | Kalispel Tribe | ■ | |
| Jamie Davis | Nez Perce Tribe | | ■ |
| Greg Haller | Nez Perce Tribe | | ■ |
| Ann Butler | WA DOE | ■ | |
| Mike Herold | WA DOE | ■ | |
| Paul Pickett | WA DOE | | ■ |
| Clayton Creager | Tetra Tech | ■ | ■ |
| George Bowie | Tetra Tech | | ■ |

It does not address issues such as vertical stratification of reservoirs, or differences between the heating of the main river channel and shallow stagnant areas near the river banks. Two- or three-dimensional models would be used for these purposes.

The temperature calculations in RBM 10 are based on well-known thermal energy budget relationships that were established by research at the Tennessee Valley Authority (TVA) during the late 1960's (Wunderlich and Gras, 1967), and which still form the basis of temperature calculations in most water quality models today. The heat exchange across the water surface includes the following processes:

- Shortwave solar radiation
- Reflected shortwave solar radiation
- Longwave atmospheric radiation
- Reflected atmospheric radiation
- Evaporative heat loss
- Heat conduction between the water and air
- Black body back radiation from the water surface

A few models designed for smaller streams in mountainous areas also include additional calculations to account for the effects of topographic or riparian shading on solar heating. However, these effects are not important for the Columbia River due to its large width and relatively unshaded exposure. Heat loads from tributaries, point sources, and nonpoint sources are added to the appropriate reaches of the model based on their temperatures and flow rates.

**Table 2**
**List of Issues Discussed at the August 6 and September 6 Meetings**

RBM 10 description

- ✓ Explain the model
- ✓ Review its application for the TMDL
- ✓ Evaluate its appropriateness

Colville temperature criteria are lower than the state criteria. How was this treated in the TMDL?

How were natural temperatures estimated?

Tribal allocations of heat

- ✓ What are the Tribal heat allocations?
- ✓ What will be the impacts of the allocations on the reservation waters?
- ✓ What are the future growth allocations?

Are the existing temperature monitoring stations adequate?

What were the assumptions for the Columbia River inflows from Canada?

What is the perspective on the application of the temperature TMDL to the Pend Oreille River?

TMDL Implementation Plans

- ✓ What form will the implementation take?
- ✓ How long will it take?
- ✓ What is currently known about the implementation plans?

Future studies for assessing potential implementation effects in Lake Roosevelt and other reservoirs (Is RBM 10 adequate, and if not, what other models should be used?)

- ✓ Stratification effects
- ✓ Adequacy of cooling water supply
- ✓ Lake water level changes
- ✓ Changes in flows, currents, residence times
- ✓ Fish habitat degradation (temperature)
- ✓ Fish entrainment
- ✓ Fish migration
- ✓ Cultural resources (lower water levels)
- ✓ Toxic sediments (lower water levels)
- ✓ Landslides (rapid drawdown)
- ✓ Macrophytes (changing water levels)

Meteorological data are required for the heat budget calculations, including the following parameters: solar radiation, cloud cover, air temperature, wind speed, relative humidity, and atmospheric pressure. Data for each portion of the river were taken from the nearest representative weather station, or from several stations when the nearest station did not measure all of the necessary information.

In RBM 10, the heat budget calculations are incorporated into a one-dimensional transport equation that simulates the advective and dispersive transport of heat as water flows through the river basin. The equations are solved using a hybrid Eulerian-Lagrangian method. This approach takes advantage of particular features of each method. The Eulerian reference frame uses a fixed spatial grid, which is convenient for referencing river location and monitoring stations and for incorporating spatial complexity. The Lagrangian reference frame moves with the flow of the water. This reference frame is used for the advective transport processes, since it reduces numerical dispersion and increases the accuracy of the results. The combined method is accurate and efficient, and has been used previously in other models.

RBM 10 is a heat budget and transport model. It requires information from a separate hydrodynamic model to provide the flow, velocity, and channel cross-section information at different locations along the rivers. This information was obtained from two different models, one for each of the two major scenarios analyzed. The Army Corps of Engineers' HEC-5Q model was run for the current impounded condition, and the Army Corps of Engineers' HEC-RAS model was run to estimate natural conditions with the impoundments removed. Both models assumed gradually varied steady flow.

Several different flow values were run to represent seasonal flow differences in the two rivers. These results were used to establish empirical relationships between flow rates and the corresponding water depths, channel widths, channel cross-sectional areas, and velocities at each location in the rivers. The Leopold and Maddock (1953) relationships were used, which expresses each variable (depth, width, cross-sectional area, velocity) as the flow rate raised to some power (exponent) and multiplied by a coefficient. The coefficients and exponents were determined from regression analysis with the hydrodynamic model results. This information was given as input to RBM 10. RBM 10 was then run with daily flow information from USGS gauging stations at various locations along the rivers to drive the transport calculations. The use of the Leopold and Maddock (1953) relationships is a standard procedure used by many river models.

RBM 10 simulations for impounded conditions assume constant geometry and simple continuity (with an assumed constant water elevation) rather than Leopold and Maddock relationships.

EPA checked the accuracy of the hydrodynamic portion of the calculations by comparing the model results with field data and performing flow balances to check continuity. The flow balances were found to be accurate to within 5 to 10 percent (Yearsley, 2002, personal communication).

Some temperature models incorporate the hydrodynamic model directly into the same model. This is particularly important for two- or three-dimensional models that simulate vertical stratification, since temperature (and the corresponding density differences) plays a major role in the hydrodynamics. However, for a one-dimensional river model, temperature does not influence hydrodynamics, so hydrodynamics can be modeled separately.

## APPLICATION OF RBM 10 FOR THE TMDL

RBM 10 was set up for the Columbia River extending from the Canadian border to the Pacific Ocean, and for the Snake River from its confluence with the Salmon River to its confluence with the Columbia River. Figure 1 shows the study area. The approximately 950 miles of rivers were divided into a series of 21 reaches, with reach boundaries established at each of the 15 dams, at 5 locations on the lower Columbia River between Bonneville Dam and the Pacific coast, and below Lewiston, Idaho on the Snake River. The reach boundaries on the lower Columbia River were below major cities or point source discharges, at the downstream end of all the point sources, and at the downstream boundary of the riverine portion of the Columbia River. River mile 4 was selected as a reach boundary since the Columbia River behaves more like an estuary than a river below this location. The TMDL analyses were performed at the downstream end of each reach. Table 3 lists the locations of the reaches. At the dams, the model temperatures represent the fore bay temperatures. Each of the 21 reaches was further subdivided into a series of smaller computational elements for the calculations, with length scales on the order of 1 to 10 miles (Yearsley, 2001).

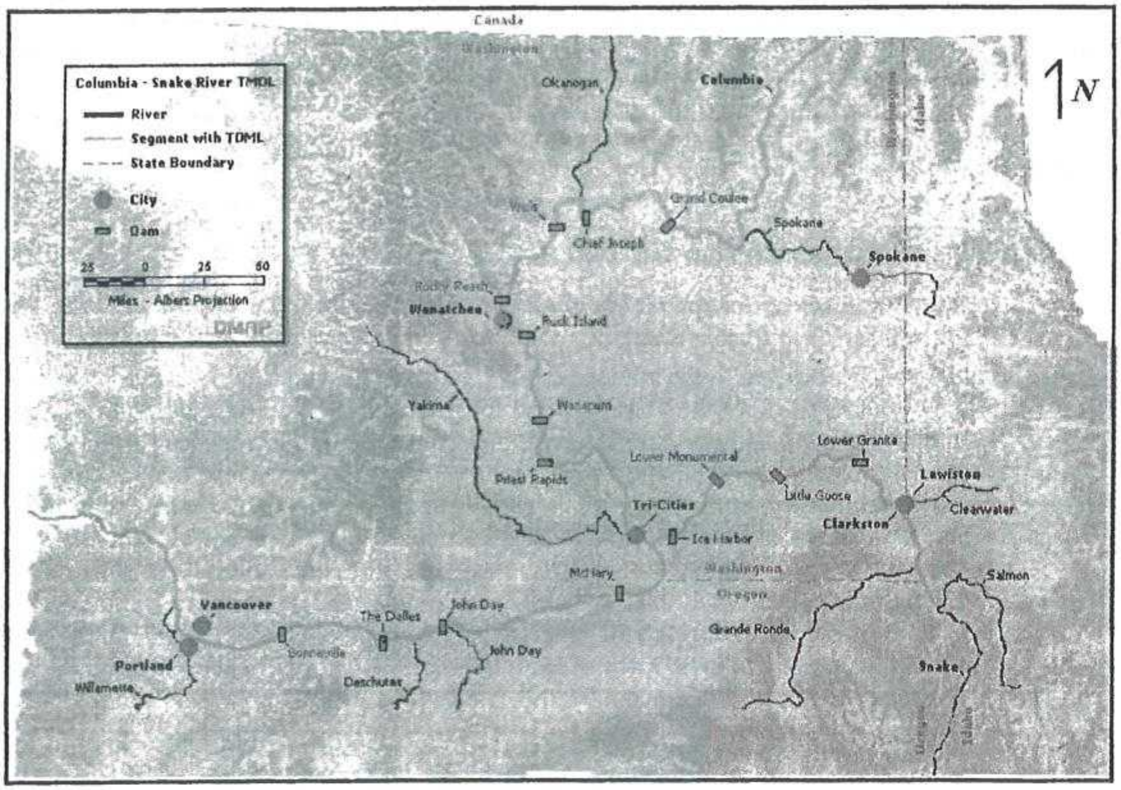


Figure 1. Reaches of the Columbia and Snake Rivers covered by the TMDL (EPA, 2002).